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A STUDY ON PHYSICO-CHEMICAL CHARACTERISTICS OF WATER IN OPENCAST COAL MINE

G. K. NIGAM[1], R. K. SAHU[2], JITENDRA SINHA[3] AND R.N. SONWANSHI[4]

Faculty of Agril. Engg. Indra Gandhi Krishi Vishyavidhyalaya, Raipur (C.G.), India.

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ABSTRACT

Coal mining is the major mining activity performed in India. Most of the coal production in India comes from opencast mines. Due to increased human population, industrialization and man-made activity water is highly polluted with different harmful contaminants. Natural water contaminates due to weathering of rocks and mining operation. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. This Paper presents a study of physico-chemical characteristics of water in opencast coal mine, Chirimiri, District Koriya, Chhattisgarh. Monthly Changes in Physical and Chemical Parameters such as Water Colour, pH, Turbidity, Total Dissolved Solids, Boron, Chloride, Calcium, Total Hardness, Total Alkalinity, Fluoride, Iron, Manganese and Nitrate. Were analyzed for a periods of one year from January – December (2013-14). All the water samples were analyzed and found that the quality of the water is good only some of the parameters like turbidity, calcium, fluoride and total hardness are slightly greater than the permissible value. Therefore there is ample scope to utilize this mine water.

INTRODUCTION

Mining operations disturb the surface topography and remove vegetations, causing excessive erosion. Open cast mining involves the excavation of large quantities of waste rock (material not containing the target mineral) in order to extract the desired mineral ore. The waste rock and the exposed bed rock walls from which it is excavated are the source of most of the metal pollution caused by mining (Carlos and James, 1997). The improvements of mining practices, significant increase the environmental risks. Industrialization and mining operation play vital role in the overall development and progress of any region. Along with the development, on the same time, it has the adverse impact on environment such as air pollution, water pollution and many others. Having mainly excessive amounts of heavy metals such as Pb, Cr and Fe, as well as heavy metals from industrial processes are of special concern because they produce water or

***Corresponding author's email :** er.nigamgk@gmail.com; er.nigamgk@yahoo.com; rksahu56@gmail.com; irapsugarcane@rediffmail.com; sonwanshi2011@rediffmail.com

[1] M.Tech. Student, Soil & Water Engineering Department, IGKV, Raipur, C.G.; [2] Dean Faculty of Agril.Engg. IGKV, Raipur, C.G. ; [3] Assistant Professor, Soil & Water Engineering Department, IGKV, Raipur, C.G. ; [4] Mining Engineer, Area Manager, Opencast Mine Chirimiri, C.G.

chronic poisoning in aquatic animals (Ellis, 1989). Mining process changes in land use/land cover due to exploration of coal minerals and subsequently the adverse impact on environment. Besides, considerable amount of solid waste piled in the form of huge overburden dumps, destruction and degradation of forest and agricultural lands, and discharge of effluents from mines into nearby water-bodies are some of the other associated problems that have adverse environmental impact (Tambekar *et al.*, 2013).

Water is one of the most important compound to the ecosystem. It is an essential component of the environment and it sustains life on the earth. Better quality of water described by its physical, chemical and biological characteristics. Human beings depend on water for their survival. Thus, estimation of quality of water is extremely important for proper assessment of the associated hazards. It is necessary that the quality of water should be checked at regular time interval for using of drinking and irrigation purpose because human population suffers from varied of water borne diseases. Water is also a raw material for photosynthesis and therefore, is important for crop production. Obviously, an optimum agricultural production depends on water and soil quality (Sachidanandamurthy and Yajurvedi, 2006). Mining affects fresh water through heavy use of water in processing ore, and through water pollution from discharged mine effluent and seepage from tailings and waste rock impoundments. The negative effect of the mining operation from the sedimentation caused by poorly built roads during exploration and disturbance of water during mine construction. These effects depend on a variety of factors, such as the sensitivity of local terrain, the composition of minerals being mined, the type of technology employed, the skill, knowledge and environmental commitment of the company, and finally, our ability to monitor and enforce compliance with environmental regulations. Due to lack of proper planning and negligence of regulations, an appreciable amount of environmental degradation and ecological damage to water, air and soil occurs (Dhar *et al.*, 1993).

Acid drainage is considered to be one of the most important and long-lasting environmental concerns at hard rock and coal mines. However, the emphasis on acid drainage prediction has eclipsed concern over neutral and basic mine drainage, which can none theless contain elevated and potentially injurious concentrations of metals, metalloids, anions, and other contaminants (Scharer *et al.*, 2000). Mining can deplete surface and groundwater supplies. The impact on surface and ground water varies depending on the nature and chemical composition of the mine water. However, the major problem has been how to make these sources safe for human consumption as these sources are affected by natural and anthropogenic influences as well as point and non-point impacts. Water pollution and wasteful use of fresh water threaten development projects, agriculture, industry and even human existence and make water treatment essential in order to produce safe drinking water.

High levels of pollutants mainly organic matter in river water cause an increase in Biochemical oxygen demand (Kulkarni, 1997), chemical oxygen demand, total dissolved solids, total suspended solids and fecal coli form. They make water unsuitable for drinking, irrigation or any other use (Hari, 1994). Permanent natural conditions in some areas may make water unfit for drinking or for specific uses such as irrigation (Peavy *et al.*, 1986). Mining operations are associated with a number of water quality problems that include mine drainage, leaching and run off of heavy metals and sedimentation. This study brings information on water quality at open cast mine, and attempts to present a straight forward approach to using and evaluating the results of the methods used to predict water quality at mine sites and therefore examine the effects of mining on water quality.

MATERIALS AND METHODOLOGY

Study Area

The present study area of open cast mine lies in Chirimiri Coalfields of Korea District of Chhattisgarh. The coalfield is bounded by the Talchar formation on the three sides except north where the area is covered by the basalts of Deccan Trap age. Geographically it is bounded by latitudes 230 9´ to 230 11´ North and longitude 82019´ to 82021´ East (Fig. 1) Total lease of the Chirimiri colliery is of 1230 ha. This was started in 1928. The mine boundary of the opencast mine is 649.11 ha. Which consist of 331.815 ha. of forest land, 92.505 ha. of tenancy and 224.790 ha. of revenue land.

Climate

The study area comes under sub-tropical type of climate. The area experiences three prominent seasons, summer, monsoon rain and winter. The day time temperatures during peak summer season are usually varying from 36 °C to 46 °C in the second fourth night of May. In the winter conditions, set in by mid November when the average minimum temperature reaches around 9 °C. The area receives average annual and monsoon rainfall is 1390.4mm and 1265.4 respectively.

Physico-Chemical Properties of Mine Water

The rainfall events precipitation and surface runoff results in seasonal fluctuations in volume of the mine pit water. The water available in mine pit is selected for their Physico-Chemical analysis. Quality of water directly affects quality of life of inhabited population. It is very essential and important to test the water before it is used for drinking, domestic, agricultural or industrial purpose. Water must be tested with different physico-chemical parameters. Selection of parameters for testing of water is solely depends upon for what purpose we are going to use that water and to what extent we need its quality and purity. Water may contain different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities. Total 12 numbers of water samples were collected from opencast mines in the period of January - December (2013-14). The bottles were kept air tight and labeled properly for identification. These samples were brought to the laboratory for the analysis of different physicochemical characteristics like pH, total alkalinity, boron, calcium, chloride, colour, fluoride, total hardness, Iron, manganese, nitrate, calcium, turbidity and sulphate. The samples were collected in polystyrene bottles having 1000 mL capacities as per requirement of the test.

The pH is most important parameter in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. The pH was positively correlated with electrical conductance and total alkalinity (Gupta, 2004). The pH of the water samples were determined by pH meter. Alkalinity is composed primarily of carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-), alkalinity acts as a stabilizer for pH. It was determined by simple dilute HCl titration in presence of phenolphthalein and methyl orange indicators. Boron was measured by the curcumin spectrophotometric method, Calcium is measured by complexometric titration with standard solution of ETDA using Murexide (ammonium purpurate) indicator under the pH conditions of more than 12.0. These conditions were achieved by adding a fixed volume of 4N Sodium Hydroxide. Chloride was measured by titrating a known volume of sample with standardized silver nitrate solution using

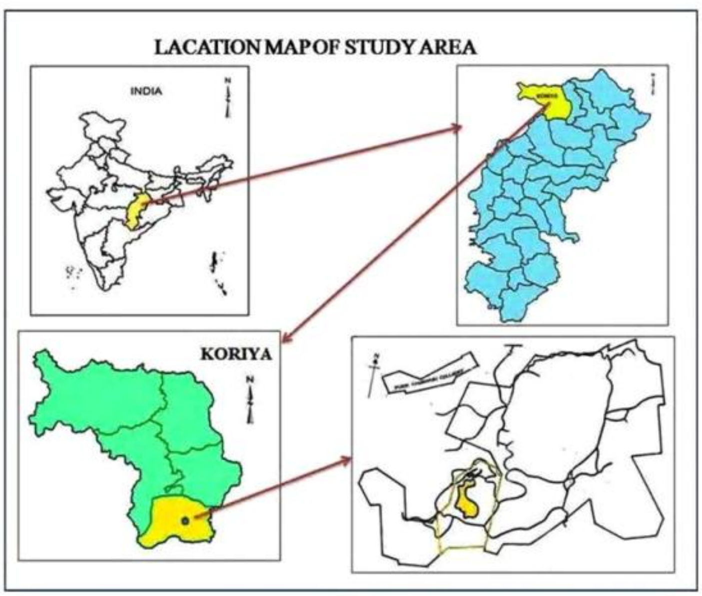

Fig. 1 Location map of study area

Table 1. Experimental methods used for analysis of water quality

S.N.	Particulars	Method used
1.	pH	Potentiometeric
2.	Total alkalinity	Titrimetric to pH=4.5 (Methyl Orenge)
3.	Boron	Curcumin spectrophotometric
4.	Calcium	EDTA Titrimetric
5.	Chloride	Argentometric Titration
6.	Colour	Visual Comparison
7.	Fluoride	Ion Selective Electrode
8.	Total hardness	EDTA Titrimetric
9.	Iron	Phenanthroline Spectropho tometric
10.	Manganese	Persulphate Spectrophoto metric
11.	Nitrate	Selective Electrode
12.	Turbidity	Nephelometric
1.3.	Dissolved solids	Gravimetric after filtration

potassium chromate solution in water in alcohol as indicator, colour was determined by visual comparison method using the Nessler tubes potassium chromate (k_2CrO_4) indicator, fluoride was determined by ion selective electrode method using stock fluoride solution, standard fluoride solution and Fluoride buffer as a reagents, the total hardness of the water sample was determined by EDTA titrimetric method using the Eriochrome Black T (EBT) as indicator, Iron was determined by phenanthroline spectrophotometric method, manganese was determined by Persulphate Spectrophotometric methods, nitrate was determined by ion selective electrode method, turbidity was measured by Nephelometric method, Nephelometers developed for measuring low turbidities and Nephelometric method of turbidity measurement is based in a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. Dissolved solids were determined by Gravimetric after filtration method. All these parameters were determined by Standard Analytical Procedures for Water Analysis, 1999, Government of India and Government of The Netherlands and these parameters were compared with IS 10500. (Table 1).

RESULTS AND DISCUSSION

It is a well known fact that clean water is absolutely essential for healthy living. Adequate supply of fresh and clean drinking water is a basic need for all human beings on the earth, yet it has been observed that millions of people worldwide are deprived of this. Freshwater resources all over the world are threatened not only by over exploitation of natural resources and poor management but also by ecological degradation. The main source of freshwater pollution can be attributed to discharge of untreated waste water, dumping of industrial effluent, and runoff from agricultural field.

Total 12 water samples of opencast mine in months of January to December (2013-14) were analyzed for their physicochemical characteristics such as pH, Colour, Turbidity, Hardness, Chloride, Alkalinity, Dissolved solids etc. and comparing the results against drinking water quality standards IS:10500. Table 2 shows the concentration of different water quality parameters of samples collected from the study area.

pH

pH is an important parameter which determines the suitability of water for various purpose. In the present investigation, pH was alkaline, values ranges from 7.3 to 8.3 (Average: 7.8). The maximum pH value was recorded in the month of April and minimum in the month of December (Fig. 2). On an average, the results of water samples of all the months showed that alkaline nature. Most of bio-chemical and chemical reactions are influenced by the pH. This results indicated all the sample within the desirable limit. The reduced rate of photosynthetic activities reduces the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH, the low oxygen values coincided with high temperature during the summer month. The higher pH values observed suggests that carbon dioxide, carbonate-bicarbonate equilibrium is affected more due to change in physico-chemical condition (Karanth, 1987; Trivedy *et al.*, 2009). Entire samples were show the alkaline nature. Generally the pH values of all the water samples were within the desirable limit. Same results were found in worked done by Simpi *et al.*, 2011.

Alkalinity (as $CaCO_3$)

Alkalinity of the water source is more significant than its pH because it takes into account the principal constituents that influence the water's ability to regulate the pH of the medium. Alkalinity increases as the amount of dissolved carbonates and bicarbonates increase (Flood, 1996; Radha Krishnan *et al.*, 2007).

Table 2. Physico-chemical parameters of monthly water samples

S.No.	Parameter*	Sampling Point in different months												IS: 10500 - 2012	
		Jan	Feb	Mar	April	May	June	Jul	Aug	Sept	Oct	Nov	Dec	Desirable	Maximum
1.	pH	7.8	8.2	8.0	8.3	8.0	7.8	7.8	7.6	7.5	7.5	8.1	7.3	6.5-8.5	6.5-8.5
2.	Alkalinity as CaCo3	68	80	136	76	40	152	108	104	96	102	104	102	200	600
3.	Boron	nill	nill	nill	0.247	nill	nill	nill	nill	nill	Nill	nill	Nill	0.5	1
4.	Calcium	41.6	16	73.6	20.8	22.4	52.8	52.8	51.6	48.4	44.6	113.6	52	75	200
5.	Chloride	46	48	29	14	22	36	14	16	18	20	32	28	250	1000
6.	Colour, Hazen units	4	2	1	2	7	6	2	2	2	1	3	2	5	15
7.	Fluoride	0.27	0.23	0.48	0.21	0.33	0.98	1.06	0.67	0.76	0.42	1.45	0.24	0.5-1.5	0.5-1.5
8.	Total hardness as $CaCo_3$	192	172	388	96	100	226	188	166	208	212	472	216	200	600
9.	Iron	0.02	0.1	0.2	0.034	0.01	0.03	0.02	0.02	0.01	0.01	0.02	0.04	0.3	-
10.	Manganese	0.01	0.02	0.01	0.082	nill	0.03	0.04	0.02	0.02	0.01	0.34	0.03	0.1	0.3
11.	Nitrate	5.32	1.72	9.3	1.13	2.22	7.08	2.21	1.32	1.31	1.32	23.04	2.32	45	100
12.	Turbidity, NTU	5	3	3	4	1	6	5	3	4	3	4	3	1	5
13.	Dissolved solids	458	342	504	142	130	554	328	316	288	296	630	244	500	2000

* (All parameter in mg/L, unless specified)

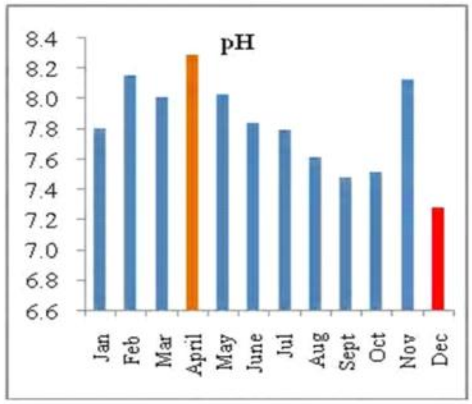

Fig. 2 pH value of water samples

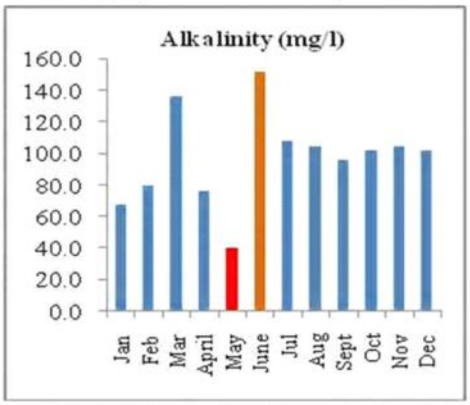

Fig. 3 Alkalinity value of water samples

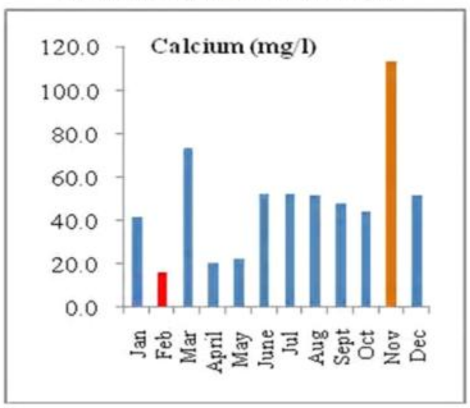

Fig. 4 Calcium value of water samples

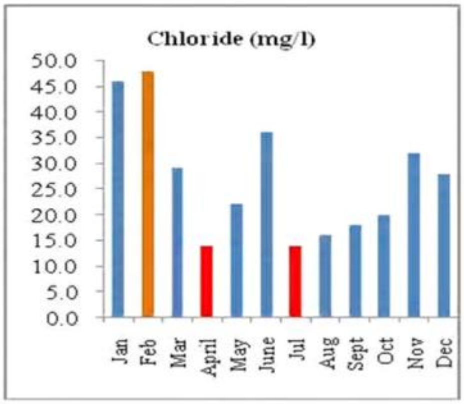

Fig. 5 Chloride value of water samples

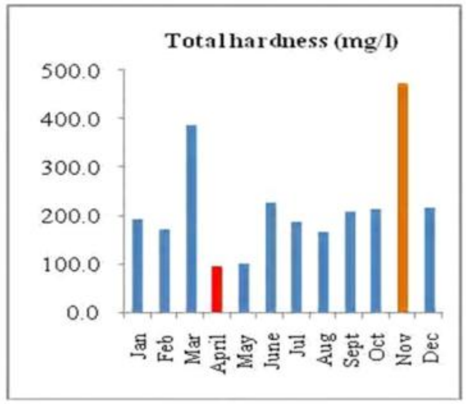

Fig. 8 Total hardness value of water samples

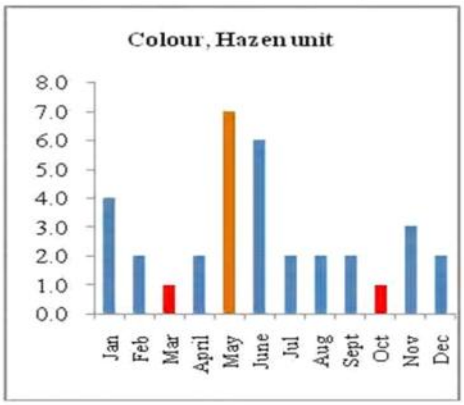

Fig. 6 Colour parameter of water samples

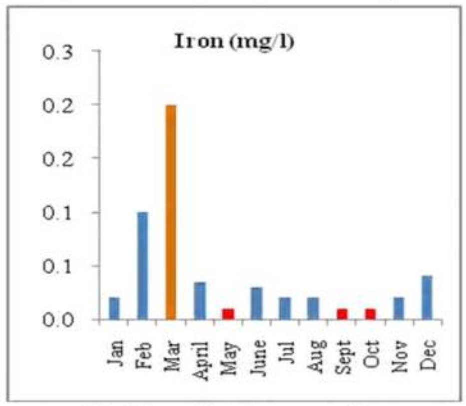

Fig. 9 Iron value of water samples

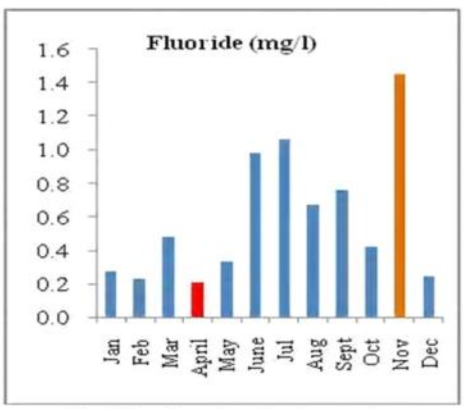

Fig. 7 Fluoride value of water samples

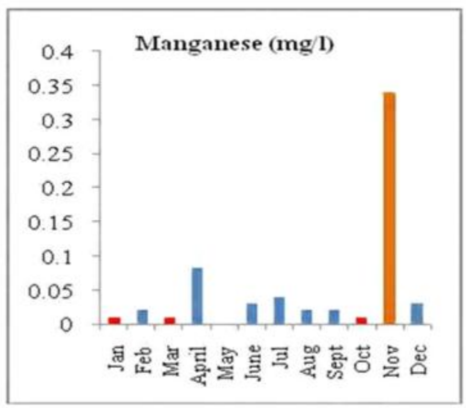

Fig. 10 Manganese value of water samples

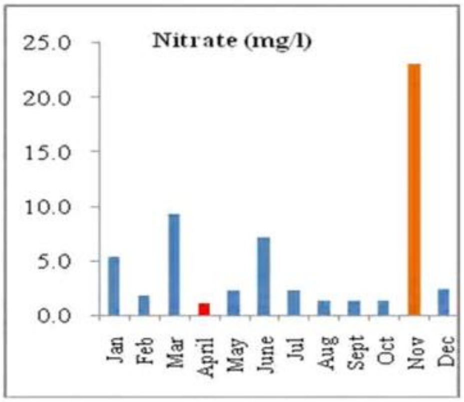

Fig. 11 Nitrate value of water samples

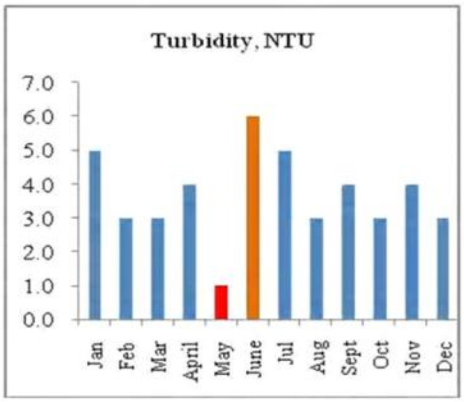

Fig. 12 Turbidity value of water samples

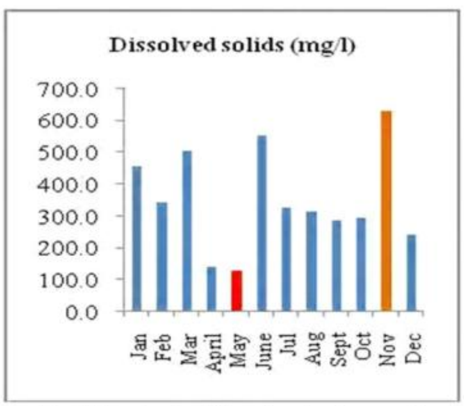

Fig. 13 Dissolved solids value of water samples

The value of alkalinity of water samples in the months of January – December was found to be ranges from 40 mg/L to 152 mg/L (Average 97.3 mg/L).

The maximum value of alkalinity was recorded in the month of Jun and minimum in the month of May (Fig. 3). The alkalinity was maximum value due to increase in bicarbonates in the water. Alkalinity values of all the water samples were showing within the desirable limit.

Boron

There was absence of boron in the entire sample except the sample of April month 0.25 mg/L. A small amount of boron is essential for plant growth, but a concentration slightly above the optimum is toxic to plants. Some plants are more sensitive to a boron excess than others.

Calcium

The presence of calcium content in samples is directly related to the hardness of water. The calcium concentration in the samples was found to be ranged between 16 mg/L to 113.6 mg/L (Average: 49.2 mg/L). The maximum value of calcium was recorded in the month of November and minimum was in the month of February (Fig. 4). Generally the calcium content of all the water samples was within the desirable limit except the November month.

Chloride

Chloride is often associated with sodium since sodium chloride is a common constituent if some water sources, the levels above 140 mg/L are considered to be toxic for plants (Flood, 1996). The chloride contents indicate domestic as well as industrial pollution (Chatterjee, *et al.*, 2002). The values of chlorides in different months were found to be various ranges from 14 mg/L to 48 mg/L (Average: 26.9 mg/L). The maximum value of chlorides was recorded in the month of February and minimum value of chlorides was in the months of April and July (Fig. 5).

Chloride is one of the most important parameter in assessing the quality of water. Munawar, (1970) is of the opinion that higher concentrations of chlorides indicate higher degree of organic pollution. Generally, the Chloride content of all the water samples was within the desirable limit.

Colour

The colour of the water sample was found to be varied from 1 to7 Hazen (Average: 2.8 Hazen). The lowest value of colour was found in the months of March and October whereas, highest was found in the month of May (Fig. 6). Generally, the colour of 83.3% the water samples was within the desirable limit except the sample of May and Jun months.

Fluoride

The fluoride content of water samples was varied from 0.21mg/L to 1.45 mg/L average (0.60 mg/L). The lowest value of fluoride was found in the months of April whereas, highest was found in the month of November (Fig. 7). Generally the fluoride content of all the water samples was within the desirable limit.

Total hardness

Total hardness is the property of water which presents the leather formation with soap and it also increased the boiling points of water. Hardness of water mainly depends upon the amount of magnesium and calcium salts dissolved (Trivedy and Goel, 1986). The value of total hardness of water samples in the present study fluctuated from 96 mg/L to 472 mg/L (Average: 219.7 mg/L). The maximum and minimum value was recorded in the month of November and April respectively (Fig. 8). 50% of the water samples were showing under the desirable limit.

Irons

Iron is the important metal for life of vegetable and animal organisms. It is undesirable for household and for industry. Iron concentration in all the samples was fluctuating from 0.01 mg/L to 0.1 mg/L (Average: 0.04 mg/L) (Fig. 9). Generally, the concentration of iron of all the samples was within the desirable limit.

Manganese

Manganese in the nature is found in form of oxides, silicates, carbonates etc. Magnesium is often associated with calcium in all kinds of water, but its concentration remains generally lower than the calcium. In the present investigation, the results of manganese of water samples in all the months were vary from 0.01-0.3 mg/L (0.1mg/L). The lowest values of concentration of manganese were measured in January, March and October whereas the highest value was measured in November (Fig. 10). Generally, the concentration of Manganese was within the desirable limit except the sample of November month (0.34 mg/L).

Nitrate

Nitrate is present final products of biological oxidation form organic pollution. Nitrate concentration depends on the activity of nitrifying bacteria which in turn get influenced by presence of dissolved oxygen. This signifies that in the most time water where polluted. The values of nitrates in the study area in different months were varied from 1.1 mg/L to 23.0 mg/L (Average: 4.9 mg/L). The lowest and highest value was measured in April and November respectively (Fig. 11). High concentrations of nitrates increase the growth of vegetation in water systems and elevate oxygen demand (Mc Junkin., 1982). Generally, the nitrate content of all the water samples was within the desirable

Turbidity

Water turbidity consists from suspense inorganic substances, dispersioned organic substances, micro microorganisms etc. Turbidity is important because it affects both the acceptability of water to consumers, and the selection and efficiency of treatment processes, particularly the efficiency of disinfection with chlorine since it exerts a chlorine demand and protects microorganisms and may also stimulate the growth of bacteria. The turbidity of water samples varied from 1 to 6 NTU (Average: 3.7 NTU). The maximum value of turbidity was found in the month of Jun whereas, the minimum value was found in the month May (Fig. 12). In the present investigation most of the water samples in all the months were found to be within the desirable to maximum limit excepted in the months of June.

Dissolved Solids

In natural waters, dissolved solids consists mainly of inorganic salts such as carbonates, bicarbonates, chlorides, sulphates, phosphates and nitrates of calcium, magnesium, sodium, potassium, iron etc. and small amount of organic matter and dissolved gases. The values of dissolved solids of the water samples ranged between 130 mg/L and 630 mg/L (Average: 352.7 mg/L). The maximum value of dissolved solids was found in the month of November whereas, the minimum was found in the month of April (Fig. 13). In the present investigation the dissolved solids in water sample of most of the months were found within the desirable limits accepts the months of April, May and November.

CONCLUSION

All the water samples were analyzed and found that the quality of the water is good only some of the parameters like turbidity, calcium, fluoride and total hardness are slightly greater than the permissible value. Therefore there is ample scope to utilize mine water for irrigation and other domestic purposes to fulfill the local needs after some treatment.

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